95 Universal Gravitation

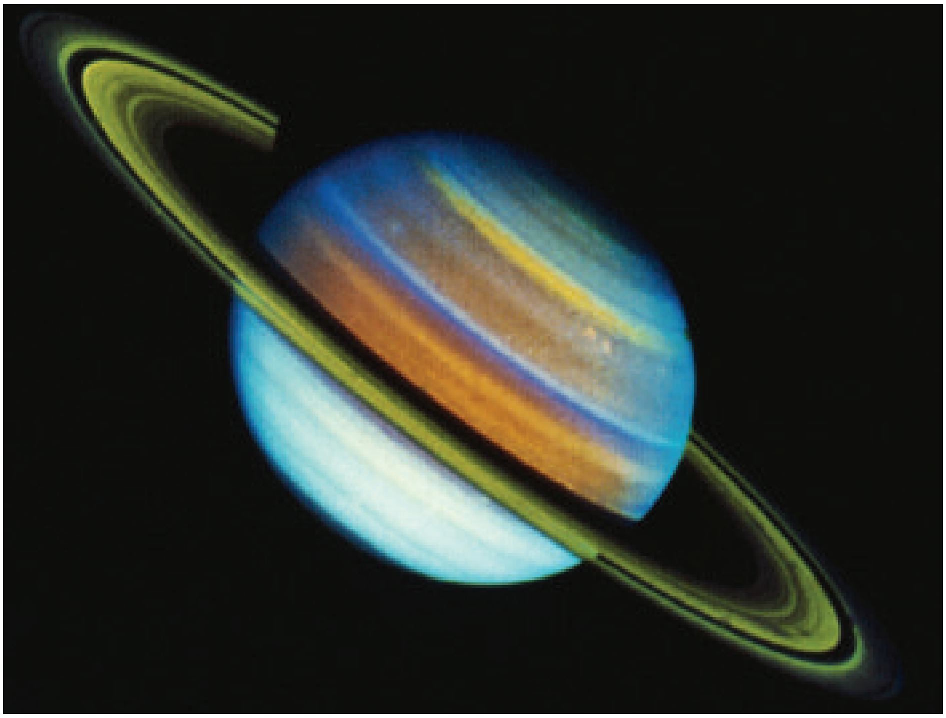
INVESTIGATION

A **force** is any push or pull. The force due to gravity interests astronomers because it is most noticeable with big objects, like stars, and reaches over long distances, such as those between the planets. **Gravity** is a natural phenomenon that causes any two objects to be pulled together. Isaac Newton's inquiry into the effects of gravity led him to determine the universal law of gravitation, which relates the force of gravity to distance and **mass.** Mass is the measurement of the amount of matter or stuff that makes up an object.

Imagine that you are a scientist who has been receiving information from a spacecraft exploring Saturn's rings. The rings reach out from Saturn for 300,000 km and contain particles of ice and rock that range in size from as tiny as a sand grain to as big as a house. Your remote sensing device got information about some of the objects in one of the rings.

CHALLENGE

What determines the amount of gravitational force between objects?



Although they look solid from Earth, Saturn's rings are actually made up of a large number of small particles each in its own orbit.

MATERIALS

For each student

1 **sheet of graph paper**

1 **ruler**

1 **Science Skills Student Sheet 4b, "Scatterplot and Line Graphing Checklist"**

PROCEDURE

1. The table below shows the gravitational force between Saturn and some particles in Saturn's rings. All of the particles are the same distance, 180,000 km, from Saturn's center.

Table 1: Mass and Gravitational Force Data

Mass of Ring Particle (kg)	Gravitational Force Between Saturn and Ring Particle (in 10,000 N)
2	23
3	35
4	47
5	58
6	70
7	82
8	93
9	105

2. Use the data in the table to make a graph of the relationship between mass and gravitational force. Label your graph "Mass and Gravitational Force."

   Hint: Put the data for mass on the horizontal axis and the data for gravitational force on the vertical axis.

3. Look at your graphed data, and record in your science notebook any relationship you notice.

4. The table below shows the gravitational force between Saturn and some ring particles that are at different distances from the planet. All of the particles have a mass of 1 kg.

Table 2: Distance and Gravitational Force Data

Distance of 1-kg Ring Particle from Center of Saturn (in 1,000 km)	Gravitational Force Between Saturn and 1-kg Ring Particle (in 10,000 N)
100	38
120	26
130	22
150	17
180	12
200	9
220	8
250	6
280	5

5. Use the data on the table to make a graph of the relationship between distance and gravitational force. Label your graph "Distance and Gravitational Force."

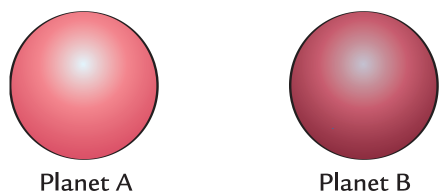
   Hint: Put the data for distance on the horizontal axis and the data for force on the vertical axis.

6. Look at your graphed data, and record in your science notebook any relationships you notice.

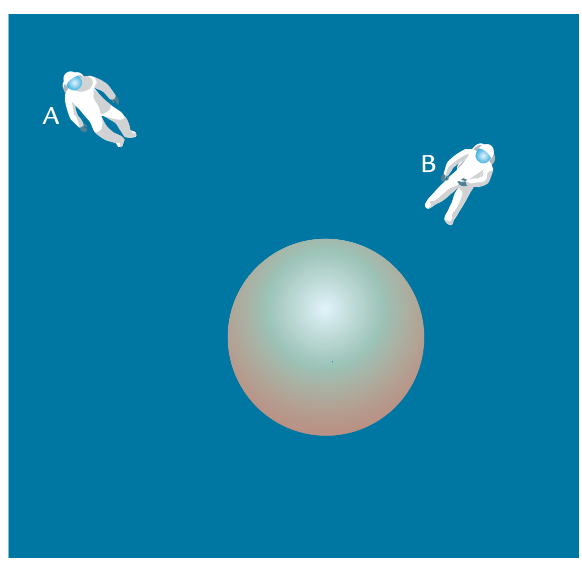
ANALYSIS

1. Compare your two graphs. Identify and explain any:
   - **a.** similarities
   - **b.** differences

2. Look at the pictures of the two planets below. Their diameters are the same, but Planet B has twice the mass of Planet A. Which one would you expect to have a stronger pull of gravity on its surface? Explain.



3. Look at the picture below of astronauts at different distances from a planet. In which position, A or B, would there be a stronger gravitational pull between the astronaut and the planet? Explain.



4. Your friend tells you that if you double the distance of a spacecraft from a planet, the gravitational pull is one half as strong. Do you think this is correct? Cite evidence from this investigation to support your position.

EXTENSION

Jupiter has about 300 times the mass of Earth. But gravity at its "surface" is only about three times the gravity on Earth's surface. Look at the Space Object Data Cards for Jupiter and Earth, shown below. Can you explain why the gravitational pull at Jupiter's "surface" is only about three times as much as Earth's?

Space Object 5 (Jupiter)

Shape: round
Orbits: the Sun
Composition: gaseous
Diameter: 143,000 km
Mass: 1,900,000,000,000,000,000,000,000,000 kg (1.9×10^{27} kg)
Other: Has rings

Space Object 11 (Earth)

Shape: round
Orbits: the Sun
Composition: rocky
Diameter: 12,800 km
Mass: 6,000,000,000,000,000,000,000,000 kg (6.0×10^{24} kg)